AIRPORT AND ACCESS MODE CHOICE IN A CONSTRAINT WORLD

Dr.rer.pol. M. Ch. Gelhausen
German Aerospace Center (DLR) - Air Transport and Airport Research
Linder Höhe, 51147 Cologne
Germany

Abstract

The purpose of this paper is to show the effects of limited airport capacity to handle air travel demand on individual airport choice of air travellers. For this, first a new method based on discrete choice theory and nonlinear programming techniques, which is applied in this study, is described briefly in a nontechnical manner. The main section of the paper is about airport choice in the Cologne region in a capacity constrained airport environment, where three qualitative different scenarios are analysed. Thereby it is possible to uncover the complex distributional changes in airport choice due to capacity constraints on the level of the individual air traveller.

1. INTRODUCTION

Capacity constraints at airports are becoming increasingly more important especially in Europe. Capacity constraints include limited physical infrastructure like e.g. runways and terminal capacity; however, in determining the overall capacity of an airport to handle air travel demand administrative restrictions like night curfews, noise & emission budgets or noise & emission limits play a role, too. Limited airport capacity may reduce negative effects of air transport on the surrounding environment of the airport. However, from the point of view of the airport and the air traveller, these constraints reduce the available capacity to handle passenger demand and change their choice behaviour. Thus, it is seems sensible to incorporate the impact of capacity constraints on future airport (and access mode) choice in a systematic and coherent way.

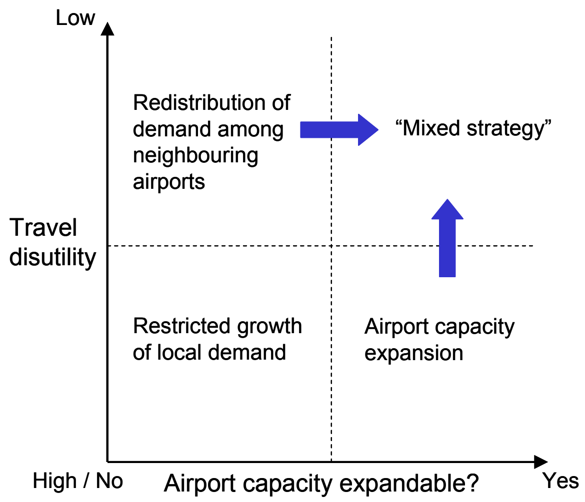

FIG 1: Impact of capacity constraints on airport choice

The first choice departure airport of an air traveller may not necessarily be realisable in a capacity limited airport environment, as demand exceeds supply at some airports, therefore some air travellers have to change their mind. However, the existence of sufficient supply at every airport is a major assumption of many airport choice models. A possible approach to model airport choice which takes account of a capacity limited airport environment endogenously is therefore described briefly in a non-technical manner. For full technical details of the algorithm the reader is referred to Gelhausen (2008b). Here, the focus lies rather on the practical consequences of limited airport capacity on airport choice of air travellers, which are demonstrated exemplarily by means of future scenarios of airport choice in the Cologne region (Gelhausen et. al. 2008), keeping analysis as simple and clearly arranged as possible to uncover the underlying mechanism.

FIG 1 illustrates three possible consequences of capacity constraints at airports:

- If travel disutility is high from the point of view of the air traveller and capacity expansion is possible, airport capacity might be enlarged.
- On the other hand, if travel disutility is low and capacity expansion is not possible, the air travel demand surplus might be served by neighbouring airports.
- However, if both travel disutility is high and capacity expansion is not possible, demand is most likely lost.

Germany has a rather dense network of airports, so the focus of the analysis lies on the second case (the northwest quadrant of FIG 1), where capacity exceeding air travel demand is served by neighbouring airports. Every few years the German Air Traveller Survey is conducted at major German airports. In 2003, more than 200 000 air travellers were interviewed at 19 international airports (e.g. Frankfurt/Main and Düsseldorf) and five regional airports (e.g. Frankfurt Hahn). The survey reveals that about 67% choose the nearest airport for departure; however, so-called spatial planning regions are served at least by three airports, whereas the maximum number is 14. On average, a spatial planning region is served by eight airports (Wilken et al. 2007, p. 172). Therefore, although two thirds of the air travellers choose the nearest airport for departure, there is a considerable degree of competition among airports.

2. METHODOLOGICAL BACKGROUND

The methodological fundament of airport and access mode choice analysis in this paper is given by the concept of discrete choice theory. The central building block in analysing choice behaviour is the assumption of individual utility maximisation. Utility serves as an abstract measure of the subjective attractiveness of an alternative derived from the alternative attributes of each alternative, like e.g. access cost, access time and supply of non-stop and low-cost flights to the chosen destination in the case of airport and access mode choice. Often this function is a weighted sum of the alternative attributes, with the weights depending on subjective preferences of the decision maker, i.e. here the air traveller. The decision maker is assumed to choose the one with the highest utility, but from an external point of view, this individual utility maximisation process is not fully measurable and thus represents a random variable. Therefore, from an external point of view, the utility function is decomposable into a deterministic component composed of the aforementioned decision-relevant alternative attributes and an additive stochastic component, which has a given stochastic distribution with expectation zero and a given variance. As a result, only evidence in form of choice probabilities relating to the alternative with the highest utility can be given. However, summed up over homogenous market segments, these choice probabilities equal market shares by alternative and market segment. FIG 2 illustrates the idea of discrete choice models (Gelhausen et al. 2008). For a detailed introduction into discrete choice models see e.g. Ben-Akiva and Lerman (1985).

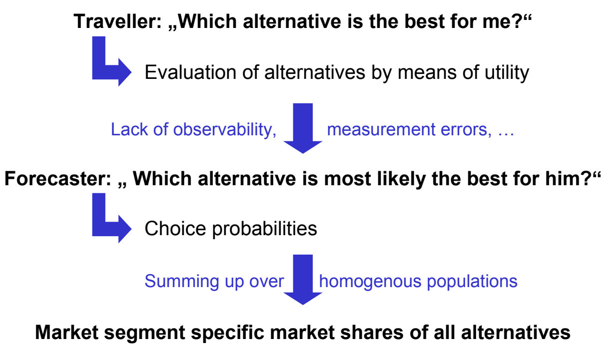

FIG 2: Concept of discrete choice models (Gelhausen et al. 2008)

The principle of individual utility maximisation is employed to integrate capacity constraints in a systematic and coherent manner in an airport and access mode choice model based on discrete choice analysis. The idea of the capacity constrained airport choice model approach is to minimise the loss of personal welfare of an air traveller caused by limited airport capacity and thus assumes air travellers adapting to capacity limits in the most economic manner.

The loss of personal welfare of an air traveller depends on the one hand on the relative attractiveness of the available alternatives, i.e. possible departure airports. The more unequal he prefers the alternatives in his choice set, the greater his personal loss of welfare due to a departure other than from his first choice airport therefore is and thus he tends to increase his efforts to depart from a certain airport. The aforementioned efforts include e.g. early booking and especially paying higher ticket prices in the long run.

On the other hand, the loss of personal welfare of an air traveller also depends on the aforementioned efforts necessary to depart from a specific airport. Therefore, there exists an equilibrium for every air traveller between the necessary efforts to depart from his first choice airport and the loss of welfare due to departing from a different airport than his first choice. These additional efforts necessary to depart from his most favoured airport, which has not enough capacity to handle its whole potential air travel demand, are represented by the so-called airport-specific “synthetic price”.

More technically spoken, available capacity of all airports is filled up simultaneously with air travel demand in decreasing order of utility differences for each air traveller until the capacity limit of an airport is reached. This individual utility maximisation process is implemented with the help of the synthetic price concept: The more air travel demand exceeds available capacity at a given airport, the higher the value of the synthetic price is for this airport. In particular, the synthetic price takes a value of zero at an airport with enough capacity to handle air travel demand. In an overall equilibrium between air travel demand and air travel supply represented by airport capacities, airport attractiveness of constrained airports is artificially reduced by means of the airport-specific synthetic prices and thereby capacity exceeding demand is reallocated to airports with free capacity according to individual utility maximisation. As a result, all capacity constraints are met with a minimum loss of personal welfare from the point of view of the individual air traveller. FIG 3 summarises the algorithm in brief.

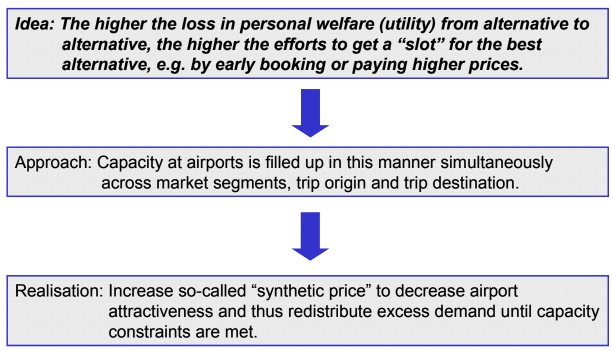

FIG 3: Modelling capacity constraints in airport choice (Gelhausen 2008a, p. 196)

3. THE IMPACT OF LIMITED AIRPORT CAPACITY ON AIRPORT CHOICE – THE COLOGNE REGION

3.1 Market segments and limited airport capacity

The model chosen to analyse airport choice in a capacity constrained airport environment is based upon an enhanced nested logit approach (Gelhausen 2007, Gelhausen 2008b). The base model is described in Gelhausen and Wilken (2006). Market segments are defined by trip purpose and trip destination:

- Journeys to domestic destinations, either for private (BRD P) or business purpose (BRD B)
- Journeys to European destinations for private purpose, subdivided into short-stay (EUR S) and holiday (EUR H) trip
- Journeys to European destinations for business reasons (EUR B)
- Journeys to intercontinental destinations, either for private (INT P) or business purpose (INT G)

TAB 1 describes the relative sensitivity by market segment with regard to limited airport capacity. The higher the value, the higher the general propensity of an air traveller is therefore to choose a different airport, if the airport capacity of his first choice airport is not sufficient to serve its whole potential demand. Hence, at least some air travellers have to choose an airport other than their most favoured, as a reason of demand exceeding supply. TAB 1 shows clearly that business travellers are more prepared to undertake additional efforts to depart from their first choice airport by e.g. paying higher prices than private travellers. As an example, if ticket prices were increased to account for the capacity situation at an airport, then an air traveller of the European business segment values 17.40 Euro as much as a private traveller of the domestic segment values 1 Euro. In this respect, the reciprocal values of TAB 1 represent the general willingness-to-pay of travellers of a certain market segment. For example, if a private air traveller to a domestic destination is willing to pay 1 Euro, then a business traveller to a European destination is willing to pay 17.40 Euro. Therefore, as a reason of the higher willingness-to-pay of the business segment, it is much more likely that a private traveller changes his mind and departs from a different airport than paying a higher ticket price at a heavily congested airport.

Market segment	Market segmet specific sensitivity to limited airport capacity
BRD Private	17,40
BRD Business	2,74
EUR Short-stay	19,75
EUR Holiday	21,55
EUR Business	1,00
INT Private	5,39
INT Business	4,45

TAB 1: Market segment specific sensitivity to limited airport capacity

However, the individual willingness-to-pay of a specific air traveller depends not only on the general willingness-to-pay of the market segment he belongs to, but also on the relative attractiveness of the airports from his individual point of view. If he perceives possible departure airports to his chosen destination very differently, his individual willingness-to-pay rises and may outweigh the general willingness-to-pay of "his" market segment, thus increasing his overall willingness-to-pay and vice versa.

Intercontinental air travellers are generally more set to pay higher ticket prices instead of choosing a different airport because of the restricted set of good alternatives. In contrast, the willingness to pay higher ticket prices as a reason of a restricted supply of capacity at some airports is comparatively low in the market segment of private domestic and private European travel, mainly because of a number of good alternative airports and more price-sensitive air travellers.

Generally, there is a tendency of business travellers crowding out private travellers and intercontinental travellers pushing away travellers to domestic and European destinations at congested airports.

3.2 Scope of the study

Subject of this study is airport choice of air travellers in the light of capacity constraints in the airport system. The Cologne region (see FIG 4) serves as an example to analyse the effects of limited capacity to handle air travel demand on airport choice as it lies in the vicinity of some airports. The study ties in with the results from Gelhausen, Wilken and Berster (2008).

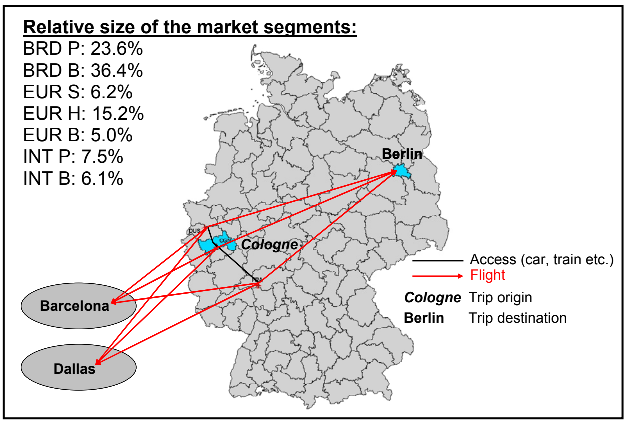

FIG 4: Scenario definition and Spatial Planning Regions of Germany (Gelhausen et al. 2008)

Furthermore, the region is well connected to the hub airport of Frankfurt/Main (FRA) by the Intercity Express (ICE), so that travel time from Cologne main station to FRA is around one hour. Air travel demand from the Cologne region is mainly served by Cologne airport (CGN), Düsseldorf airport (DUS) and FRA. Three specific destinations were chosen exemplarily to analyse airport choice by market segment:

- Berlin for domestic air travel
- Barcelona in Spain for European air travel
- Dallas in the USA for intercontinental air travel

All three aforementioned airports are connected by a direct flight service to Berlin and Barcelona, however, only FRA serves Dallas via a direct flight.

Low-cost flights play a major role especially in European air travel. Both CGN and DUS offer low-cost flights to Barcelona, however, the weekly flight frequency is significant higher at DUS than at CGN (28 flights/week vs. 7 flights/week in summer 2005).

Necessary data for analysis originates from different sources (Berster et al. 2005; Die Bahn 2005a, b, c; Deutsche Flughäfen 2005; INVERMO 2005; OAG 2005; Taxi 2005; Verkehrsverbünde 2005). Market segments were weighted by actual travel volume in summer 2005 by the aforementioned three destinations in the subsequent analysis of airport choice in the light of limited capacity. Their relative size is illustrated in FIG 4.

3.3 Scenario 1: Limited capacity at DUS

FIG 5 shows the market share of DUS by market segment against its unsatisfied demand potential. The demand potential of a specific airport is the number of air travellers, who want to depart from this airport. For example, 0.05 corresponds to 5% of air travellers who want to depart from DUS to their chosen destination; however, they have to depart from a different airport because of insufficient capacity at DUS to handle its whole demand potential. The crucial question now is which individual air travellers precisely belong to the unsatisfied demand potential and which airport they choose instead. If we e.g. expect to increase air travel demand by 100% in the next 15 years, a value of 0.75 represents a scenario in which DUS is able to handle 50% of the additional demand developing in the future. A value of 0 on the x-axis corresponds to a scenario with sufficient capacity at DUS; thus it is possible that every air traveller chooses his first choice airport he wants to depart from. All other airports are assumed to be constraint-free in the first scenario; however, this assumption is removed successively in further scenarios to show more complex interactions between several capacity constraints.

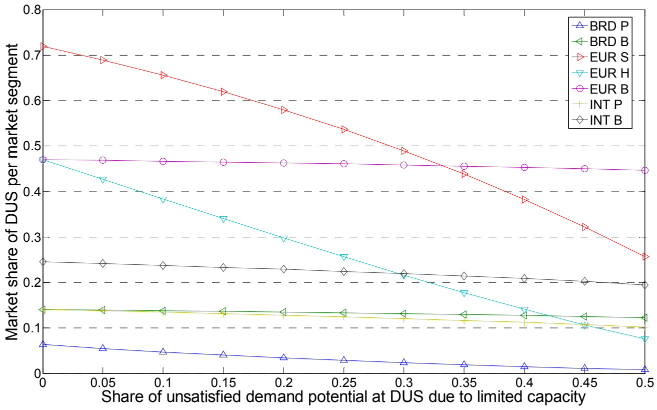

FIG 5: Market share of DUS by market segment against unsatisfied demand potential

If airport capacity at DUS is limited and potential demand exceeds supply, the crowding-out effect is mainly at the expense of private air passengers travelling to domestic and European destinations as FIG 5 illustrates. For example, the share of short-stay travellers to European destinations reduces from 72% to 26%, if DUS can just handle 50% of its demand potential. Likewise, the share of holiday travellers reduces from 47% to about 8%. However, the assumption of DUS only being able to serve half of its (future) demand is rather severe and not a realistic option for at least the near future, but it only serves to show the underlying mechanism and thus punctuates the effects of limited capacity to handle air transport demand on individual airport choice.

In contrast, the business segments are comparatively stable: The share of domestic business travel declines from 14% to 12%, the market share of European business travel reduces from 47% to 45% and intercontinental business at DUS is reduced from 25% to 19%.

FIG 6 shows the market share of neighbouring airports against the unsatisfied demand potential of DUS. The total market share of DUS decreases from 23% to 12%, if DUS can only handle 50% of its demand potential. The demand surplus of DUS is mainly served by CGN: Its total market share rises from 71% to 82%, whereas the share of FRA remains around 4% to 5%. The airports Dortmund (DTM), Frankfurt Hahn (HHN) and Niederrhein (NRN) serve a negligible share of the demand and their market share increases just marginally.

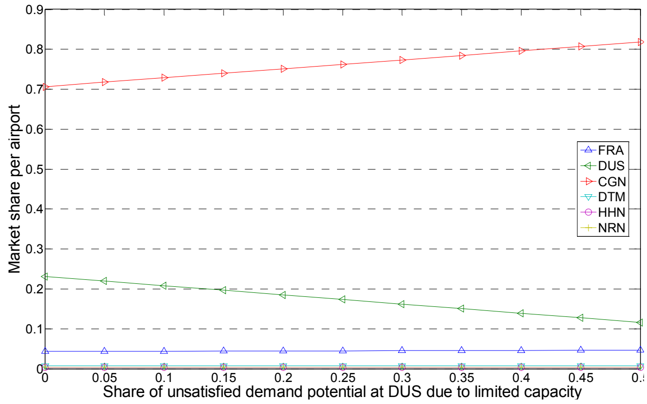

FIG 6: Market share by airport against unsatisfied demand potential at DUS (scenario 1)

3.4 Scenario 2: Limited capacity at DUS and CGN

In this scenario, CGN is assumed to operate already at its capacity limit and therefore cannot absorb any demand surplus of DUS such as in scenario 1. The purpose of this scenario is to show the effects of limited airport capacity on airport choice without having a likewise airport nearby, serving as a substitute for the unsatisfied demand potential at the original constrained airport. The market segment specific results of limited air transport capacity at DUS under the assumption of CGN operating at its capacity limit are very similar to scenario 1 (FIG 5); therefore analysis is focussed on market share by airport.

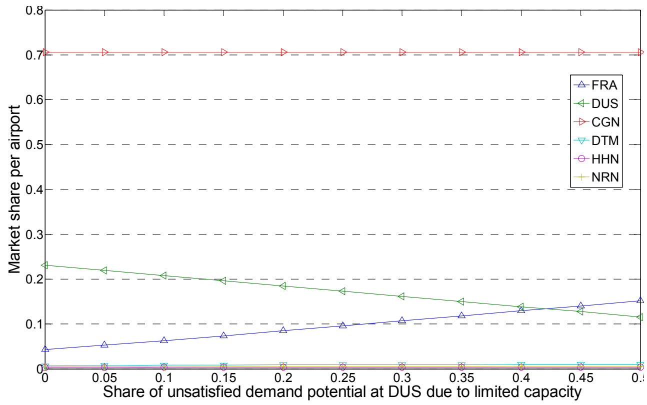

FIG 7: Market share by airport against unsatisfied demand potential at DUS (scenario 2)

FIG 7 shows the market share of neighbouring airports against the unsatisfied demand potential of DUS. The total market share of DUS again decreases from 23% to 12%, if DUS can only handle 50% of its demand potential. The demand surplus of DUS is now mainly served by FRA, as a reason of CGN being assumed to be already at its capacity limit in this scenario: The total market share of FRA rises from 4% to 15%. The airports DTM, HHN and NRN in turn serve only a negligible share of the demand and their market share increases just marginally with increasing gap between demand potential and demand actually served at DUS. This is mainly a result of FRA having enough free capacity and being the better substitute than DTM, HHN and NRN because of the good access from the point of view of the Cologne region and the better supply of non-stop flights to the aforementioned destinations. Here, the ICE plays a major role in providing good surface access from the Cologne region to FRA.

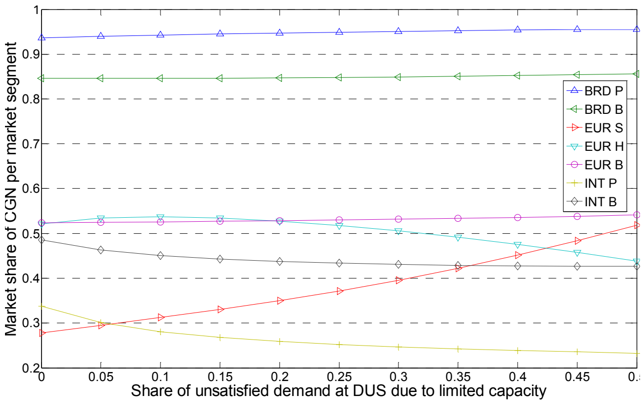

FIG 8: Changes in passenger distribution at CGN against unsatisfied demand potential at DUS

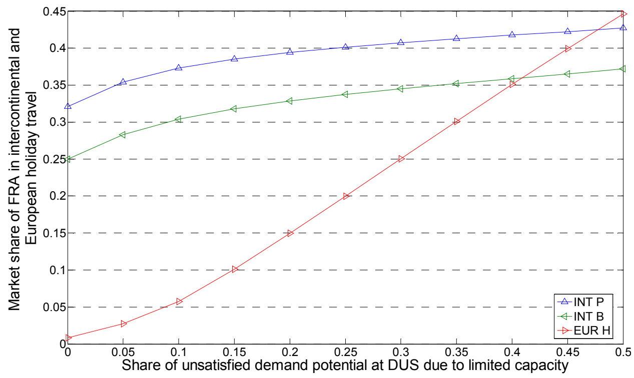

FIG 9: Market share of FRA in intercontinental and European holiday travel against unsatisfied demand potential at DUS

However, although the overall air transport demand at CGN remains constant due to the capacity limit, there are distinct distributional changes among the seven market segments as FIG 8 illustrates. There is a slight increase in market share in the segments of domestic and European business travel, but the market share of short-stay air passengers to European destinations at CGN increases rather strong from 28% to 52%. On the other hand, the market share of holiday travellers at CGN first steps up with increasing distance between demand potential and demand actually served at DUS to 53%, but then falls to about 44%. The changes in market structure at CGN occur at the expense of the segments of intercontinental travel to Dallas: Private travel falls from 34% to 23% and business travel from 49% to 43%. They mainly switch to FRA and due to the good surface access and supply of non-stop flights the losses in personal welfare of these air travellers are rather small.

FIG 9 displays the distributional effects of limited air transport capacity at DUS and CGN on the market segments of intercontinental and European holiday travel to Dallas: The market share of FRA rises from 32% to 43% in the segment of private intercontinental travellers and from 25% to 37% in the intercontinental business segment depending on the gap between demand potential and demand actually served at DUS. The increase in market share in European holiday travel is even stronger: The share of FRA lies in a range between 0.08% and 45% depending on the capacity deficit in DUS.

FRA is an attractive alternative as a departure airport for intercontinental travel to Dallas and European holiday travel to Barcelona from the viewpoint of the Cologne region, as it offers non-stop flights to both destinations and access time is acceptable due to the high-speed intercity connection (ICE) between Cologne main station and FRA: Travel time is about 65 minutes. Therefore, about half of the passengers departing from FRA to Dallas or Barcelona take the ICE to the airport (see TAB 2).

Market segment	**Share of ICE passengers at FRA**
INP P (Dallas)	50.8%
INT B (Dallas)	47.9%
EUR H	54.9%

TAB 2: Share of ICE passengers at FRA

Indeed, this substitution effect from DUS to FRA in intercontinental and European holiday travel works in a large part across CGN, thus not being unidirectional but rather complex in structure, as FIG 8 illustrates. However, the major assumption of this scenario is enough capacity at FRA even to handle the demand surplus of DUS and therefore e.g. no capacity constraint-induced increase in ticket price, which is rather unrealistic, but in this case it is a main reason for many holiday travellers to choose FRA. This leads over to the third scenario with capacity limited at FRA, too.

3.5 Scenario 3: Limited capacity at DUS, CGN and FRA

In the last scenario presented, both CGN and FRA are assumed to operate already at their capacity limit and therefore they cannot absorb any demand surplus of DUS such as in scenario 1 and 2, respectively. The aim of the last scenario is to show the impact of limited airport capacity on airport choice without having any likewise airport within a medium distance, thus there is no airport with a comparable supply of flights nearby serving as an almost perfect substitute for the unsatisfied demand potential at the original airport. The market segment specific results of limited air transport capacity at DUS under the assumption of CGN and FRA operating at their capacity limit are again very similar to scenario 1 (FIG 5) and thus analysis is focussed on market share by airport.

FIG 10 shows the market share of airports serving a significant amount of air travel demand of the Cologne region in this scenario against the unsatisfied demand potential of DUS. Like the other two scenarios, the total market share of DUS decreases from 23% down to 12%, if DUS can only handle 50% of its demand potential. As FRA and CGN cannot absorb any demand surplus from DUS by scenario definition, excess demand is now mainly served by the smaller airports DTM, HHN and NRN: The total market share of DTM rises from 0.7% to 6.9%, the market share of HHN increases from 0.3% to 1.9% and the market share of NRN rises from 0.05% to 3.0%.

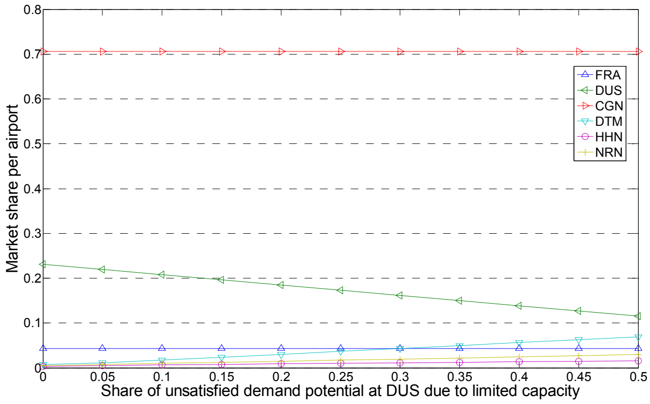

FIG 10: Market share by airport against unsatisfied demand potential at DUS (scenario 3)

TAB 3 illustrates the effects of limited capacity as described in this scenario on market segment specific airport choice. Here, DUS is assumed to only handle 50% of its demand potential and neither FRA nor CGN can absorb any excess demand. If we look at airport choice as a whole, any demand surplus is served by the airports DTM, HHN and NRN and thus this represents a zero-sum game: The overall demand increases at DTM, HHN and NRN as much as it decreases at DUS, because FRA and CGN cannot absorb any demand surplus from DUS, thus their overall demand level remains the same. However, on a microscopic level, i.e. on the level of the individual air traveller, there are significant, in part even massive changes concerning the question which air passenger departs from which airport. TAB 3 shows these changes at the aforementioned six airports by market segment. However, the assumption of DUS only being able to serve half of its (future) demand is as already outlined above rather severe and not a realistic option for at least the near future, but it only serves to show the underlying mechanism and thus punctuates the effects of limited capacity to handle air transport demand on individual airport choice.

	FRA	**DUS**	**CGN**	**DTM**	**HHN**	**NRN**
BRD P	0.32%	-5.25%	-9.24%	12.95%	0.01%	0.06%
BRD B	0.04%	-1.53%	0.87%	0.42%	0.00%	0.01%
EUR S	0.51%	-49.50%	14.56%	11.45%	5.62%	8.70%
EUR H	7.44%	-38.60%	9.35%	9.23%	2.78%	8.24%
EUR B	0.05%	-1.90%	1.84%	0.00%	0.00%	0.00%
INT P	-7.90%	-7.89%	-13.82%	9.69%	5.81%	8.18%
INT B	-10.95%	-2.01%	7.81%	1.90%	0.93%	1.43%

TAB 3: Differences in market share due to limited capacity at DUS

As a reason of limited capacity, DUS loses market share in all market segments, however, the distribution is very uneven. The losses are by far greater in the segments of travel for private purposes than for business reasons. This is mainly due to the fact that business travellers have a higher general willingness-to-pay, as already illustrated by TAB 1. For example, the share of European short-stay travellers at DUS decreases from a basic value of 72% to 22.5% by 49.5 points. The basic values are represented by the “no-constraints-scenario”, which can be found for DUS and CGN in FIG 5 and FIG 8, respectively. Losses in market share in the business segments at DUS are very small and they are mainly absorbed by CGN and DTM. The airport CGN faces a rather large increase in market share in private European travel and intercontinental business travel, however these increases are largely at the expense of private domestic and international travel, since overall airport capacity at CGN is fixed in this scenario and thus any changes in market segment air travel demand at CGN are a zero-sum game overall. Travellers of both segments switch to the smaller airports of DTM, HHN and NRN and take a stop-over flight instead.

However, these small airports increasing their market share in intercontinental private travel thus much is essentially a result of the assumptions of the scenario, i.e. DUS can only handle half of its demand potential and no air traveller cancels his journey altogether. This also leads to large losses in personal welfare of air travellers, as many of them depart from much less attractive airports from their point of view. However, this scenario serves to show the complex interrelations between the general willingness-to-pay of an air passenger and the relative attractiveness of an airport given a specific destination, which together determine the individual willingness-to-pay of a specific air passenger: Private travellers have a low general willingness-to-pay compared to business travellers and thus are crowded out at DUS much more with increasing capacity constraints, which lead to higher prices at DUS at least in the long run. Private air passengers to European destinations mainly switch to CGN, DTM, HHN and NRN partly because of the good supply of low-cost flights compared to other airports and partly because of these airports being situated nearest and having still free capacity, and thus displacing some private travellers to domestic and intercontinental at CGN, which in turn mainly switch to DTM. Apart from the increase in access time and access cost, the airport DTM is not such much worse than CGN from the point of view of an air passenger, which originally wanted to depart from CGN to an intercontinental destination via a stop-over flight.

Interestingly, FRA loses some market share in intercontinental travel. This is due to some European holiday travellers, who rather prefer a better supply of non-stop flights instead of a lower ticket price, switching from DUS partly to FRA with overall capacity being fixed there. Therefore, the share of some market segments has to decline, so that the capacity constraint is not violated. Some private intercontinental air travellers thus depart from a smaller airport like e.g. DTM instead and take a cheaper stop-over flight, whereas some intercontinental business travellers depart from Cologne due to the shorter access and take a stop-over flight as well. The disadvantage of a stop-over flight from CGN is at least partially compensated by the significantly better access to the airport.

The last scenario shows very clearly how capacity constraints at one airport may induce secondary capacity constraints effects at other airports and thus leading to considerable spill-over effects. These spill-over effects cause at least complex distributional changes in individual airport choice and may even lead to capacity constraints at previously unconstrained airports.

4. SUMMARY AND CONCLUSIONS

This paper first shows briefly how to allow for capacity constraints in airport choice models based on discrete choice theory. The chosen approach combines discrete choice theory with methods of nonlinear programming techniques to implement capacity constraints. Thereby, it is possible to analyse the impact of future capacity constraints at airports to handle air transport demand on airport choice.

The main section of this paper is about the practical aspects of how insufficient capacity to handle air passengers affects individual airport choice. The study is conducted by means of the example of the Cologne region, which is mainly served by the three airports DUS, CGN and FRA in the case of sufficient capacity. To allow for qualitative different conditions regarding the capacity situation, three scenarios are analysed: In the first case, only DUS has insufficient capacity to handle all potential air passengers, in the second case, both DUS and CGN are limited in airport capacity and the last scenario assumes all three airports to be limited in capacity. In each scenario, different levels of insufficient capacity for DUS are analysed.

The study shows the significant effects of limited capacity to handle air travel demand at an airport on the choice behaviour of individual air travellers and uncovers the individual changes in airport choice, especially in a decentralised airport environment like in Germany. These effects reach out far beyond the original airport suffering from capacity constraints.

Insufficient capacity at some airports leads to demand being distributed among more airports and in a different way unlike the case of sufficient capacity at every airport. Thereby, even airports without limited airport capacity are affected, as demand is distributed differently among market segments in the light of capacity constraints at other airports, even though the overall demand level is unchanged. In general, there is a strong tendency of business travellers crowding out private air travellers at congested airports, as their general willingness to pay is much larger in most cases compared to the leisure segment. However, a second important factor, which determines crowding-out effects, is the relative attractiveness of the airports from the point of view of the individual air traveller and his chosen destination. If possible departure airports are perceived very differently by the individual air passenger, his individual willingness-to-pay rises and may outweigh the general willingness-to-pay of the market segment he belongs to. Therefore, universally valid conclusions are not possible and have to be made on an individual case-by-case basis.

Competition may decrease at congested airports; however, small remote airports are the beneficiaries, as their market share increases. Depending on initial conditions and the extent of capacity constraints, spill-over effects can even lead to capacity constraints at even more airports, thus intensifying the effects of limited airport capacity to handle air travel demand. From the point of view of the air traveller, personal welfare is reduced, as e.g. travel time and travel cost increase or he has to take a more unfavourable flight.

5. REFERENCES

Ben-Akiva, M.; Lerman, S. (1985). Discrete Choice Analysis: Theory and Applications to Travel Demand. Cambridge.

Berster, P.; Gelhausen, M. Ch.; Pabst, H.; Wilken, D. (2005). Die regionale Struktur des Personenluftverkehrs in Deutschland im Jahr 2005 und ein Modell zur Deskription und Prognose von Zubringermodus- und Flughafenwahlentscheidungen. Cologne (unpublished).

Die Bahn (2005a). Sonderauswertung des Personenverkehrs. Frankfurt.

Die Bahn (2005b). Elektronischer Fahrplan Regionalverbindungen.

Die Bahn (2005c). DB ReiseService.

Deutsche Flughäfen (2005). Lagepläne von 22 ausgesuchten deutschen Flughäfen. Verschiedene Orte.

Gelhausen, M. Ch. (2007). Ein Generalized Neural Logit-Modell zur Prognose von Flughafen- und Zugangsverkehrsmittelwahl. Cologne.

Gelhausen, M. Ch. (2008a). Impact des contraintes de capacité sur le comportement des voyageurs. Proceedings of Séminaire de Direction générale de l'Aviation civile, 13 décembre 2007, Paris, France.

Gelhausen, M. Ch. (2008b). Airport Choice in a Constraint World: Discrete Choice Models and Capacity Constraints. Paper presented at the 12th Air Transport Research Society Conference 2006 in Athens, Greece.

Gelhausen, M. Ch., Berster, P.; Wilken, D. (2008). Airport Choice in Germany and the Impact of High Speed Intercity Access: The Case of the Cologne Region. Journal of Airport Management, 2(4), in press.

Gelhausen, M. Ch.; Wilken, D. (2006). Airport and Access Mode Choice - A Generalized Nested Logit Model Approach. Paper presented at the 10th Air Transport Research Society Conference 2006 in Nagoya, Japan.

INVERMO (2005). Sonderauswertung zum Projekt INVERMO, Institut für Verkehrswesen, Universität Karlsruhe. Karlsruhe.

Official Airline Guide (OAG) (2005). Market Analysis. Dunstable.

Taxi (2005). Taxi-Tarifumfrage. http://www.ventil-taximagazin.com.

Verkehrsverbünde (2005). Fahr- und Tarifpläne 2005. Verschiedene Orte.

Wilken, D., Berster, P., Gelhausen, M. Ch. (2007). Airport Choice in Germany - New Empirical Evidence of the German Air Traveller Survey 2003. Journal of Airport Management, 1(2), pp. 165 - 179.